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A COMPREHENSIVE METHODOLOGY FOR COMPUTER-FAMILY SELECTION

by

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The practice of computer selection and the existing solutions for a computer-family selection procedure are briefly described. Then, Saaty's Analytic Hierarchy Process is presented and incorporated into the selection methodology. The result is a structured and comprehensive methodology that allows decision makers to rank the alternatives more objectively and select a computer-family that best fits the needs of the entire organization. Illustrative examples are embedded in the text to demonstrate the application of the various steps in the proposed methodology.

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A Comprehensive Methodology for Computer-Family Selection

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Abstract

This paper presents a selection methodology for a computer-family. The proposed methodology incorporates the Analytic Hierarchy Process in the evaluation procedure and aims at helping organizations in selecting a family of computers from the a manufacturer's product line, rather than a specific computer model.

The practice of computer selection and the existing solutions for a computer-family selection procedure are briefly described. Then, Saaty's Analytic Hierarchy Process is presented and incorporated into the selection methodology. The result is a structured and comprehensive methodology that allows decision makers to rank the alternatives more objectively and select a computer-family that best fits the needs of the entire organization. Illustrative examples are embedded in the text to demonstrate the application of the various steps in the proposed methodology.

Keywords: Computer-family, Computer selection, Analytic Hierarchy Process.

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1. Introduction

The advent of computers and data communications technology has brought about major changes in organizations' computerization process. Motivated by increases in their size, sophistication and geographic dispersion, many organizations distribute or decentralize their information systems [Ahituv and Neumann, 1986; Ahituv et al. 1989; Cash et al., 1988]. This phenomenon requires a close control of the computer acquisition process in order to maintain maximum compatibility among dispersed systems. Thus, rather than selecting a specific machine for known and identified needs, organizations are often faced with the problem of selecting a group of systems that will work in harmony, sharing files and data. Such a group of systems is called a computer-family and is defined as:

> *Computers of the same type, consisting of several models from the same manufacturer's product line, ranging from microcomputer to mainframe, with full compatibility in the operating system and the system's software, to enable transfer of application software from one family member to another without change* [Borovits and Zviran, 1987].

An example of a computer-family is Digital Equipment Corporation's (DEC) following line of products: VAX 8978, 8974, 8842, 8840 and 8820 mainframe computers, VAX 8810, 6240 and 6230 super-minicomputers, VAX 6220 and 6210 minicomputers and VAX 8250, Microvax 2000 and 3600 and Microvax II as super-microcomputers. Another example consists of Prime's 6650 and 6350 mainframe computers, Model 6150 super-minicomputer, Models 4450 and 4150 minicomputers, and Prime models 4050, 2455, 2450 and 2350 as super-microcomputers.

Compatibility in hardware and software precludes the system integration problem encountered with mismatched systems. The benefits of system-wide compatibility are exemplified by the ability to transfer application software from one family member to another using a common operating system.

This paper concerns the problem of computer-family evaluation and selection. It describes the existing methods for computer selection, presents Borovits and Zviran's (1987) generic methodology for computer-family selection and Saaty's (1977) Analytic Hierarchy Process. It, then, proposes a comprehensive methodology to deal with this issue. A hierarchy of selection criteria is developed and the application of various steps in the proposed methodology is demonstrated throughout the paper.

2. Computer Selection Procedures

The traditional computer selection process consists of the following stages:

- Analyzing the requirements and computing needs of the organization.
- Determining and defining the requirements for the computer system.
- Sending the request for proposal (RFP) to qualified vendors.
- Screening, evaluating, validating and comparing the proposals.
- Selecting the best alternative.

[Timmreck, 1973; Joslin, 1977; Borovits, 1984; Borovits and Zviran, 1987; Shoval and Lugasi, 1987].

The fourth stage, focusing on the actual screening and evaluation of the proposals, is the core of the selection procedure. A variety of models and methods for this stage have been intensively discussed in the literature. Figure 1 outlines the existing

computer selection methodologies and the basic reference for each of them (a summarized description of these methodologies can be found in: Borovits, 1984; Borovits and Zviran, 1987; Shoval and Lugasi, 1987).

Insert Figure 1 about here

These methods, however, address the problem of selecting a specific computer or computers to meet specific and known requirements. None of them provides a tool to evaluate and select a computer-family as defined above.

3. Computer-Family Selection

Selecting a computer-family is more complex than selecting a specific computer system. In selecting a computer-family, an organization cannot evaluate competing products on a one-to-one basis (e.g., DEC's VAX 6230 and Prime 6150), but rather focus on a comparison of groups of computers with similar characteristics (e.g., DEC's versus PRIME's mainframes, super-minicomputers, etc.).

Borovits and Zviran (1987) have first tackled this issue and proposed a generic methodology for the selection of a computer-family. Their methodology consists of the following ten steps:

1. Identification of possible vendors and manufacturers
2. Preliminary elimination of irrelevant candidates
3. Determination of mandatory requirements
4. Examination of vendor's compliance with mandatory requirements

5. Setting quantitative and qualitative criteria and respective weighting-scales
6. Writing the RFP to be addressed to selected vendors
7. Receiving, comparing and analyzing bids
8. Drawing up a final list of vendors
9. Benchmarks for performance of hardware and software
10. Final conclusions and selection of the best computer-family

This methodology provides a framework for carrying out the computer-family selection process. It has, however, two major drawbacks:

a. It does not encompass an objective weighting technique for setting the weighting -scale for the qualitative and quantitative criteria (step 5). It rather addresses the need of doing so and proposes a list of relevant selection criteria that should be considered. The relative weights for these criteria are assigned subjectively.

b. It suggests the use of the weighted scoring method for comparing and analyzing bids (step 7). A major drawback in this method is that it might be influenced by subjective considerations. Thus, using subjective weighting and scoring can reduce the overall effectiveness of the process. It also does not allow an examination of consistency by the evaluators.

These two issues are addressed in the proposed methodology. An objective weighting and scoring technique - Saaty's Analytical Hierarchy Process - is integrated into the selection methodology to improve the selection process. Thus, the new

methodology is more comprehensive and aims at aiding decision makers in the computer-family selection process.

4. The Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) was introduced by Saaty (1977) as a method for assessing the importance of a large number of interacting factors, develop priorities among the factors and choose a best alternative in an objective manner [Saaty, 1977, 1981, 1982].

The method is based on a pairwise comparison between all relevant factors. In each pairwise comparison, a decision maker evaluates two factors and answers the question: "Which of the following two factors dominates the other, and by how much ?". The first part of the question is clearly an ordinal question, while the second part is a cardinal one, requiring a numerical input. The answer is based on a nine-point numerical scale, as defined by Saaty (1977) and presented in Figure 2.

Insert Figure 2 about here

The answers to these evaluations comprise the input data for a *comparison matrix*. The size of this matrix for n factors is nxn. Each cell represents a pairwise comparison between two factors, showing the relative contribution (to the subject of comparison) of the *i*th element as compared to the *j*th element. The matrix has positive entries everywhere and satisfies the reciprocal property, i.e., $a_{ij} = 1/a_{ji}$. Therefore, when the *ij*th element of the matrix is specified, the *ji*th position is automatically determined by its

reciprocal value. Thus, the number of pairwise evaluations required for n factors is $\frac{1}{2}(n^2-n)$. Figure 3 depicts an example of a comparison matrix of six factors.

Insert Figure 3 about here

After a comparison matrix is filled, its eigenvector corresponding to the largest eigenvalue is calculated and normalized so that the total sum of its elements is 1. The values of this normalized eigenvector (right column in Figure 3) constitute the factors' relative weights.

Another matter of concern is the quality of the answers provided in the comparison matrix and, in particular, the problem of consistency. This is assessed by considering whether $a_{ij} = (a_{ik})*(a_{kj})$ holds for all triplets. The *consistency ratio* (CR) is calculated for the maximum eigenvalue and is required to be less than 0.1 for acceptable consistency.

Seidmann and Arbel (1985) present an application of the AHP to the process of microcomputer selection. They analyze a large number of attributes to compare microcomputers from several vendors and provide a case study to demonstrate the applicability of their method. Their use of the AHP technique facilitates the determination of both weights and scores for each attribute for each alternative, using matrices to perform pairwise comparisons between alternatives. The total number of matrices in their example equals the number of attributes and the dimension of every matrix is the number of alternatives. Once all weights and scores are obtained, the final score of each alternative was calculated using the weighted scoring technique.

5. A Comprehensive Methodology for Computer-family Selection

The proposed methodology is an elaboration of Borovits and Zviran's methodology. It is based on incorporating Saaty's Analytic Hierarchy Process into the process of weighting the selection criteria (step 5) and during the evaluation of competing computer-families (step 7). Figure 4 presents the proposed methodology where the AHP technique is incorporated into steps 5.6 and 7.3.

Insert Figure 4 about here

The application of the AHP to steps 5 and 7 of Borovits and Zviran's methodology will make the resolution of ranking and weighting alternatives less arbitrary. In step 5, the AHP allows a decision maker to objectively create a prioritized and weighted list of criteria. At each level of the hierarchy, every criterion can then be compared to all the others in its group, on a one-to-one basis. Using the scale and descriptions from Figure 2, a score for each pairwise comparison is obtained. These scores are inserted into a comparison matrix to compute the relative weight of each criterion by Saaty's method, as well as the consistency ratio.

Step 7 consists of the process of receiving, comparing and analyzing bids. This represents a second opportunity for incorporating the AHP technique into the selection process. After assigning each relevant model from each proposed computer-family to a category (e.g., mainframe, supermini, mini, micro), each category is evaluated in accordance with the criteria established in step 5. The advantage in applying the AHP to this step is achieving greater objectivity as categories of computers from different

manufacturers' product lines are evaluated on a one-to-one basis.

Following is a step-by-step description of the proposed methodology:

Step 1: Identification of possible vendors and manufacturers. This step involves a search of all vendors whose product-lines might suit the organization's needs, in accordance with the definition of a computer-family. The output of this step is an initial list of vendors whose product-line may suit the organization's needs.

Step 2: Determination of mandatory requirements . Mandatory requirements define the basic features that are required from a computer-family. These requirements are derived from the basic definition of a computer-family as well as from the organization's information systems (IS) policy. The output of this step is a set of requirements (e.g., full compatibility of system's software, ability to upgrade each model to a higher one without change in software and operating procedures, etc.), which are considered as prerequisites for a vendor's candidacy.

Step 3: Examination of vendor's compliance with mandatory requirements. Based on the mandatory requirements, information regarding each vendor's compliance with these requirements is obtained (e.g., by a questionnaire) from all potential vendors and examined by the selection team.

Step 4: Preliminary elimination of irrelevant candidates. The list of vendors (output of step 1) is screened and those suppliers that do not comply with the mandatory requirements are winnowed out. The vendors remaining after this elimination procedure constitute the mailing list for the Request For Proposals (RFP).

Step 5: Setting quantitative and qualitative criteria and respective weighting scale. This step focuses on establishing the evaluation framework, within which all bids will be

analyzed. In order to select a computer-family that best fulfills its requirements, an organization must designate the qualities that will be used to compare the computer-families. These qualities, or characteristics, are called selection criteria.

All criteria used in the evaluation process can be sorted in a hierarchical scheme, as illustrated in Figure 5. The top of this hierarchy is denoted as "Total score of a computer-family". The second level consists of the division to qualitative and quantitative criteria. The next level within the quantitative criteria defines the categories of computers and the subsequent levels define specific attributes by which the competing families will be evaluated. Criteria at each level are the descriptors of a criterion of the next higher level. The lowest level consists of atomistic elements which describe specific characteristics and by which the specific computer models are to be evaluated.

Insert Figure 5 about here

Step 5 is broken into the following seven sub-steps:

Step 5.1. *Prioritize the overall importance of qualitative versus quantitative criteria.* The criteria used to evaluate computer-families are either quantifiable or non-quantifiable. The qualities that are not quantifiable are referred to as qualitative criteria while those characteristics that are quantifiable and measurable by an established standard are called quantitative criteria. Because both qualitative and quantitative criteria used in the evaluation process, the first step is the determination of the relative weights, or percentage of the total score, for each of these groups of criteria. This is a subjective decision, and since only two factors are involved (qualitative criteria and quantitative criteria), it is made without the use of the AHP.

Step 5.2. *Set qualitative criteria.* Qualitative criteria are used to describe general characteristics of a vendor or a computer-family which, although nonquantifiable, are important to the overall evaluation process. Figure 6 illustrates a multi-level hierarchy of qualitative criteria.

Insert Figure 6 about here

Step 5.3. *Select applicable computer categories.* In accordance with the definition of a computer-family, vendors are expected to propose a wide variety of elements rather than a single computer. This raises a problem of comparing proposals from different vendors. To overcome this problem, a scheme of computer categories is to be established, each of which represents differences in computing power and major hardware characteristics. This will enable a classification of each proposed system into a specific category and evaluation of categories of computers rather than specific systems.

Thus, the development of the quantitative branch of the selection criteria scheme starts with the definition of applicable computer categories. An example of such a classification might consist of:

- Mainframe
- Super-minicomputer
- Minicomputer
- Super-microcomputer
- Microcomputer

Step 5.4. *Set quantitative selection criteria.* Quantitative selection criteria describe the major measurable characteristics for each computer and are applied to each of the

categories designated in Step 5.4. As proposed by Borovits and Zviran (pp. 110-111), the quantitative criteria should usually address the following common issues: hardware, software, communication, conversion and environment. These criteria constitute the fourth level in the hierarchical scheme.

Step 5.5. *Select sub-criteria for each criterion, down to the lowest level.* Elaborate on each criterion, set in the previous step, and develop appropriate sub-criteria. The sub-criteria selected represent a break-down of each criteria and should be valid and meaningful items of comparison that can be applied to the actual evaluation of the proposed computer-families. An example of a criteria pertaining to hardware characteristics is presented in Figure 7.

Insert Figure 7 about here

Step 5.6. *Prioritize and weight all categories, criteria and sub-criteria.* This step focuses on assigning a relative importance to each category, criterion and sub-criterion, using Saaty's AHP process. As already described, the AHP method consists of a pairwise comparison of elements at each level of the hierarchy. Every element being compared is rated against all other elements in the same level, on a one-to-one basis. A value is obtained, based on the scheme presented in Figure 2, and inserted into a comparison matrix. The size of the matrix equals the number of elements being compared and recommended to be limited to 5-9 items (Saaty, 1982). The normalized eigenvector of matrix generates a relative weight for each element. The total value of all the weights generated for each group being compared is 1.

As an example, assume that the classification of computers (step 5.3) yielded three categories - mainframe, minicomputers and microcomputers - which are to be prioritized. To determine the relative weight for each category, a decision maker has to compare each category with the other two, one at a time, and assign a numerical value that best represents the intensity of importance of one category over the other.

The numerical values are inserted into a comparison matrix and their reciprocals are calculated for the corresponding cells, as illustrated in Figure 8. Then, the normalized eigenvector is calculated to represent the relative importance of each of the items being evaluated. the consistency ratio is computed to ensure the consistency of all responses and weights.

Insert Figure 8 about here

Step 5.7. *Calculate the absolute weights for all criteria and sub-criteria.* The absolute weight for a criterion is computed by multiplying its relative weight by the relative weight of each of its predecessors in the hierarchy, or by the absolute weight of its immediate predecessor.

Figure 9 presents an example of absolute weight calculation.

Insert Figure 9 about here

The process demonstrated in Figure 9 is completed for each criterion in the hierarchy of a computer-family. These weights represent the maximum absolute values

that a given computer-family can score in the evaluation process (step 7). Absolute weights of sub-criteria at the lowest level of the hierarchy are used in calculating the absolute scores in step 7.

Step 6: Writing the RFP to be addressed to selected vendors. The RFP consists of a summary list of specific requirements according to which vendors will be asked to write their proposals. Following the evaluation scheme, the RFP should include two parts. The first focusses on quantitative criteria and relates to each computer model within a proposed family. The second is more general in nature and addresses qualitative criteria. It concentrates upon issues such as uniformity and transferability of systems software, conversion of present applications software to the new computer-family, environmental considerations, etc. The RFP is mailed to vendors according to the mailing list created as the output of step 4. It is required that the bids be submitted in writing and it is expected that they will conform to the style indicated in the RFP, so that the selection process will not be affected by style of expression and use of selling techniques.

Step 7: Receiving, Comparing and analyzing bids. In response to the RFPs, bids for proposed computer-families will have been received. These bids have to be analyzed and evaluated as a basis for selecting the highest rated computer-families for final evaluation in steps 8, 9, and 10. This evaluation is performed in six sub-steps:

Step 7.1. *Assign each relevant model from each proposed computer-family to a category, according to predetermined criteria.* Computer categories have been established in step 5.3. This stage focuses on classifying each model from each proposed computer-families to an appropriate computer category so it is evaluated by the criteria already set for that category.

The determination as to which category a computer will be placed is based on, but not limited to, such factors as CPU performance, memory size, external storage capacity, number of disk drives, cost, etc. The decision as to what factors will constitute placement into a particular category will have been determined when the categories were selected in Step 5.3.

Step 7.2. *Design comparison tables for each category.* Once all proposed models have been classified to categories, comparison tables are designed. These tables summarize the characteristics of each proposed model within each given category. A separate table is designed for each category. An outline is presented in Figure 10.

Insert Figure 10 about here

Step 7.3. *Evaluate each computer model in accordance with the criteria established in Step 5.* This stage provides a second opportunity for incorporating the AHP technique in the selection procedure. During this stage, each computer model is evaluated within the category he is assigned to. If a vendor proposes more than one model in a given category, all proposed models are evaluated. Computer models in a given category are compared by criterion, using the AHP technique. A pairwise comparison of these models is performed and a value, based on the AHP technique, is obtained. After all values for a criterion are obtained, the relative scores and consistency ratio are calculated using the procedure described in step 5.6. All scores are recorded in an evaluation table as outlined in Figure 10.

Step 7.4. *Calculate the absolute score for each criterion and each computer model.* Based on the evaluation tables designed in the previous step, the absolute score is calculated. It is computed by multiplying the relative score (outcomes of step 7.3) and the absolute weight of each criterion, as calculated in step 5.7. A formal representation of this computation is:

$$S_j = R_{ij} * W_{ij}$$

Where:

S_j = absolute score attained by a specific computer model, for a given criterion j

R_{ij} = relative score attained by a computer model in category i, for criterion j, on scale of 0-1

W_{ij} = absolute weight of criterion j in category i (as calculated in Step 5.7), on scale of 0-1

In each category, S_j is calculated for all computer models. Based on these scores, a comparative table is drawn up, showing the absolute scores attained for each criteria by each computer model. This table uses the same outline as illustrated in Figure 10.

Step 7.5. *Calculate the total score for each computer model.* Based on the comparative tables (output of previous step), the total score for each computer model in each category is computed over all criteria as:

$$S = \sum_{j} S_j$$

Where:

S = overall score attained by a specific computer model

S_j = absolute score attained by a specific computer model (output of step 7.4), for a given criterion j.

Step 7.6. *Calculate the total score for each computer-family.* The final stage in evaluating the bids focuses on scoring the computer-families. The overall score for a computer-family consists of a summation of the highest absolute score attained by a member of a family member in each category. Based on the comparative tables (output of the previous step), the total score for each computer-family is computed as:

$$T = \sum_{k} S_k$$

where:

T = total score for a computer-family

S_k = best absolute score attained by a specific family member, in category k.

Step 8. *Drawing up a final list of vendors.* On the basis of the final scores attained by each computer-family, the selection committee is able to disqualify irrelevant computer-families, and select up to three or four vendors most likely to succeed. These computer-families are then further tested to ensure they have the proper capabilities and characteristics.

Step 9. *Benchmarks for performance of hardware and software.* A benchmark, in the context of this discussion, is a set of live tests designed to examine the characteristics and actual performance of the proposed systems (hardware and software). One category of benchmark tests aims at verifying cardinal characteristics of the proposed computer families (e.g., uniformity of the operating system and application software, ease of converting existing applications to the proposed family). Another type of benchmark tests refers to examining the systems performance using common production measures. Examples of such measures include total throughput and transaction volume load, which

delineate the expected capacity of the system to handle the anticipated average workload. Another measure, peak load handling, refers to the system's response to temporary added load. The selection of issues and criteria to be tested is performed according to their importance for an organization using the relative weights already assigned.

Step 10. Final conclusions and selection of the best computer-family. After benchmarks have been performed and all essential characteristics of a proposed computer-family have been deemed satisfactory, a selection committee will review and reconsider the relevant scores assigned to each competing computer-family.

Finally, the committee will pick the best as the one recommended to be an organization's computer-family. The recommendations will then be submitted to an organization's management for approval and adoption. A problem faced by those involved in the selection process is how to compare criteria and how to prioritize them according to their importance to the decision making process. There will be a large number of criteria, some quantifiable and others non-quantifiable, whose importance to the selection process will be compared with each other.

6. Discussion and Conclusion

The need to develop a comprehensive methodology for computer-family selection arises from the trend towards distributing computing resources. Organizations with distributed or decentralized systems, or in the process of carrying out decentralization of computing resources, should be in a position to evaluate and select a computer-family rather than a specific computer model.

Selecting a computer-family will ensure a uniform computing environment for the entire organization. This environment provides full compatibility in both hardware and systems software and minimizes the cost of systems integration. Moreover, the ability to transfer application software from one family member to another without any change avoids duplication in software development and lays the foundation for coordinated development and implementation of consistent and organization-wide information systems. Another advantage lies in the ability to focus on a one-time effort for the evaluation and selection process.

The process of selecting a computer-family is a complex procedure. The goal for a decision maker, responsible for selecting a computer-family, is to select the correct line of products for an organization rather than a specific computer. Because of the complexity of the selection process, a formalized methodology makes the process more structured and objective.

The methodology presented here provides a comprehensive framework to carry out the selection process. It allows the designation of a hierarchy of selection criteria, based on the organizational needs. Once criteria have been selected, they are objectively prioritized and weighted using the AHP technique, establishing their net value and absolute weight for the overall evaluation process. Each computer model within proposed computer-families is then evaluated and scored separately, in accordance with the prioritized and weighted criteria. The total score for a computer-family is based on the aggregation of final, absolute, scores of the best performing family members in each category.

By following the procedure presented in this paper, the process of selecting a computer-family is made reliable and objective. The end product of this process, a computer-family that best meets the needs of an organization, may be chosen with the knowledge that the correct computer-family was selected.

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Selection Method	Basic Reference
Weighted Scoring	Sharpe, 1969
Cost-Value	Timmreck, 1973
Dynamic Approach	Ein-Dor, 1977
Present Value	Roenfelt and Fleck, 1976
Cost-Effectiveness Ratio	Joslin, 1977
Requirement Costing Technique	Borovits, 1984
Eigenvector Model	Seidmann and Arbel, 1984
Lexicographical Ordering	Ahituv and Neumann, 1986
Multi-Attribute Utility Model	Shoval and Lugasi, 1987
Efficient-Frontier Model	Shoval and Lugasi, 1988

Figure 1: Existing methods for computer selection

Level of Importance	Definition	Explanation
1	Equal importance of the two factors	The two factors contribute equally
3	Weak importance of factor i over factor j	Experience and judgment slightly favor one factor over another
5	Strong importance of factor i over factor j	Experience and judgment strongly favor one factor over another
7	Very strong importance of factor i over factor j	One factor is strongly favored and its dominance is demonstrated in practice
9	Absolute importance of factor i over factor j	The evidence favoring one factor over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between two adjacent scale values	Compromise is needed between two levels
Reciprocals	If factor i has one of the preceding numbers assigned to it when compared with factor j, then factor j is assigned with the reciprocal value when compared with factor i	

Figure 2: The comparison scale for Saaty's method

	Factors						Eigen-
	A	B	C	D	E	F	-vector
Factor A	1	2	3	2	1/2	1/3	.15
Factor B	1/2	1	2	2	1/2	1/3	.12
Factor C	1/3	1/2	1	1/2	1/4	1/6	.05
Factor D	1/2	1/2	2	1	1/3	1/4	.08
Factor E	2	2	4	3	1	1/2	.23
Factor F	3	3	6	4	2	1	.37
							1.00

Maximum eigenvalue for this matrix = 6.10

Consistency Ratio = .016

Figure 3: Scoring factors using Saaty's AHP: an example

Step 1. Identification of possible vendors and manufacturers.

Step 2 Determination of mandatory requirements.

Step 3 Examination of vendors' compliance with mandatory requirements.

Step 4 Primary elimination of irrelevant candidates.

Step 5. Setting quantitative and qualitative criteria and respective scales.

5.1.	Prioritize overall importance of qualitative and quantitative criteria.
5.2.	Set qualitative criteria
5.3.	Select applicable computer categories.
5.4	Set quantitative criteria
5.5.	Select sub-criteria for each criterion down to the lowest level.
5.6.	Prioritize and weight all categories, criteria and sub-criteria.
5.7.	Calculate the absolute weights for all criteria and sub-criteria.

Step 6. Writing the RFP to be addressed to selected vendors.

Step 7. Receiving, comparing, and analyzing bids.

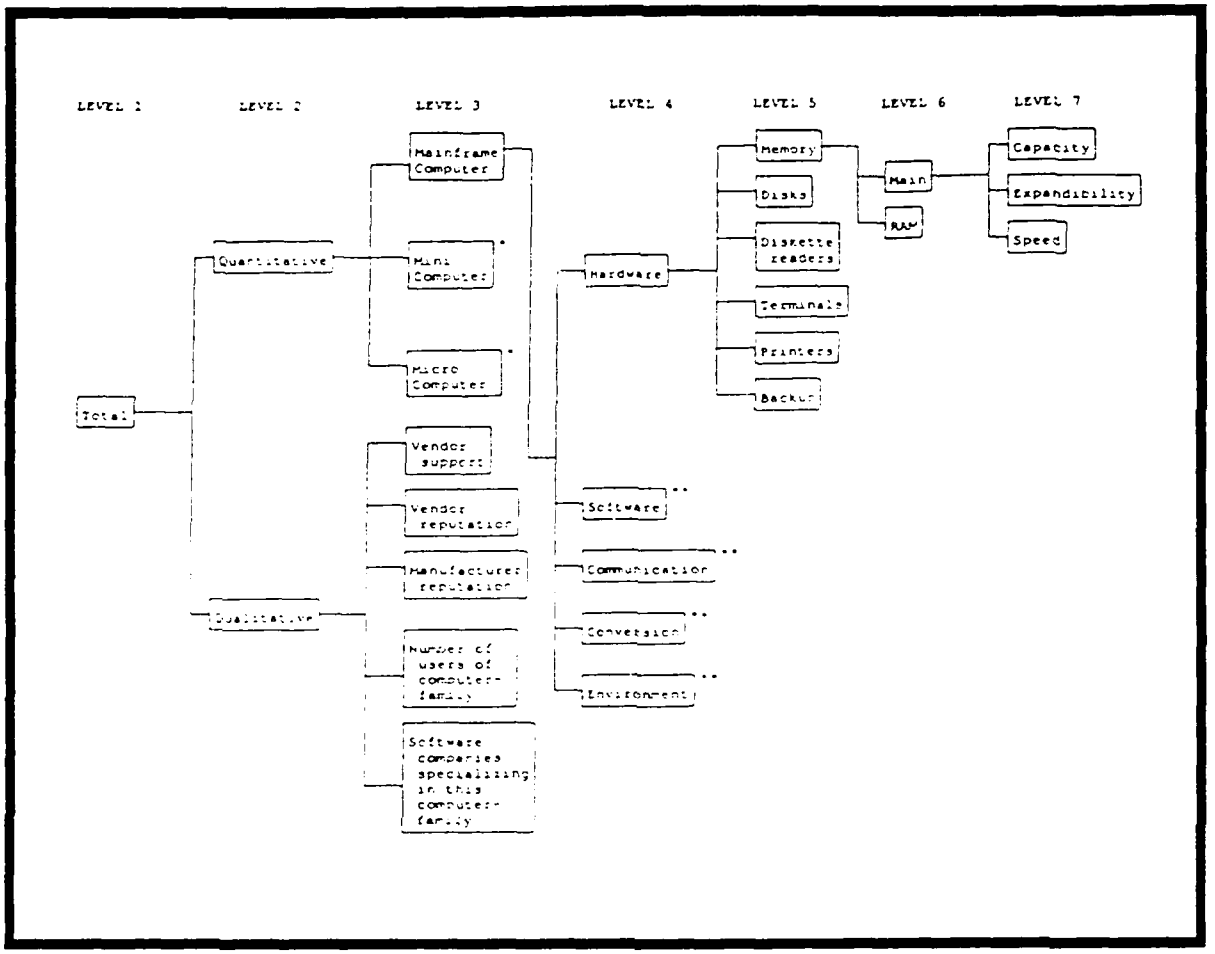
7.1.	Assign each relevant model of computer from a proposed computer-family to a category.
7.2.	Design comparison tables for each category
7.3.	Evaluate each computer model in accordance with criteria established in Step 5.
7.4.	Calculate the absolute score for each criterion and each computer model
7.5.	Calculate the total score for each computer model
7.6.	Calculate the total score for each computer family

Step 8. Drawing up a final list of vendors.

Step 9. Performance of hardware and software benchmarks.

Step 10. Drawing final conclusions and selection of best computer-family.

Figure 4: A comprehensive computer family selection methodology: A workflow diagram



* Quantitative criteria in levels 4-7 are replicated for all computer categories

** These criteria are further broken down (see Figure 7 for more details)

Figure 5: Hierarchy of criteria

Level 1	Level 2	Level 3	Level 4
Total score			
	Qualitative criteria		
		Vendor support	
			Implementation assistance
			Technical trouble-shooting
			Training
			Documentation
		Vendor reputation	
			User opinions
			Trade journal evaluations
		Spread of use	
			Number of organizations
			Number of installed systems
		Software houses specializing in this computer-family	

Figure 6: Detailed List of Qualitative Criteria

Level 4	Level 5	Level 6	Level 7
Hardware			
	Memory		
		Main	
			Word size
			Standard capacity
			Maximum capacity
			Units of expansion
			Speed
		RAM	
			Capacity
			Expendability
		Cache	
			Capacity
			Expendability
	Disks		
		Maximum number of drives	
		Minimum capacity	
		Maximum capacity	
		Average access time	
		Data transfer rate	
	Tapes		
		Maximum number of drives	
		Density	
		Read/Write speed	
		Data transfer rate	
	Diskette drives		
		Maximum number of drives	
		Diskette size	
		Density	
		Read/Write speed	
	Data channels		
		Minimum number of channels	
		Maximum number of channels	
		Average transfer rate	
	Terminals		
		Monitors	
			Monochrome
			Color
			Graphics capabilities
		Keyboards	
			Number of keys
			Design
	Printers		
		Dot matrix	
			speed
			line size
		Letter quality	
			speed
			line size
		Line	
			speed
			line size
		Laser	
			speed

Figure 7: Detailed List of Criteria, Hardware

	Main--frame	Mini computer	Micro computer	Relative weights
Mainframe	1	3	3	.59
Minicomputer	1/3	1	2	.25
Microcomputer	1/3	1/2	1	.16
				1.00

Maximum eigenvalue for this matrix = 3.05

Consistency Ratio = .043

Figure 8: Calculating relative weights for computer categories

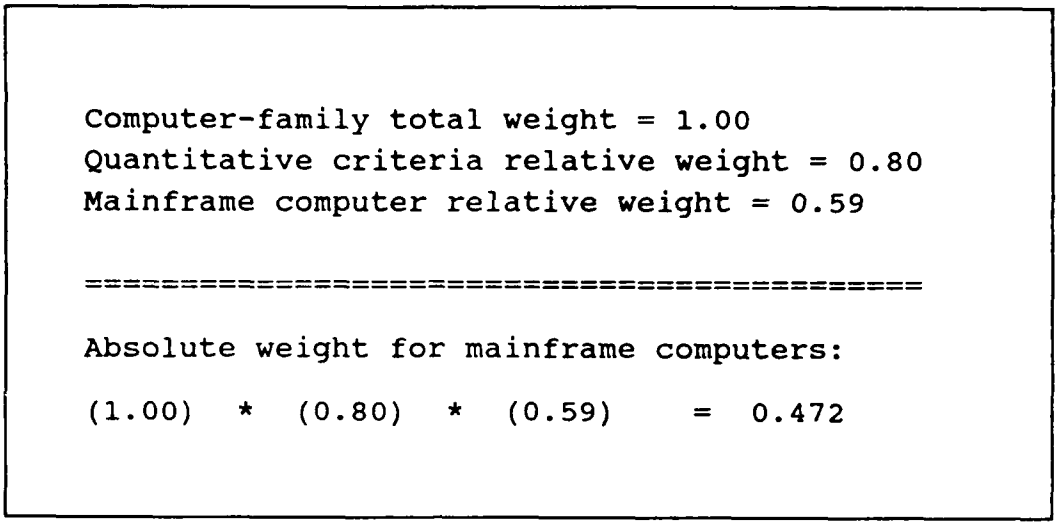


Figure 9: Computing the absolute weight of mainframes

Mainframe comparison table

Criteria	Vendor A			Vendor B		Vendor C
	Model A1	Medel A2	Model A3	Model B1	Model B2	Model C1
Crit. 1						
Crit. 2						
Crit. 3						
. . .						

Figure 10: Outline of a comparative table.

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